

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-131216

(43)Date of publication of application : 18.05.1999

(51)Int.Cl.

C23C 14/06
B23B 27/14

(21)Application number : 09-312817

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(22)Date of filing : 29.10.1997

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(54) COATED HARD TOOL

(57)Abstract

PROBLEM TO BE SOLVED: To improve the adhesion of a hard coating film by specifying the ratio of the diffraction intensity between the (200) plane and the (111) plane in the X-ray diffraction of compd. coating of TiAl and third component, composing the third components of Si or the like are interposing a metallic alloy layer composed of Ti, TiAl or TiAl and third components with a specified thickness on the space between a substrate and the coating film.

SOLUTION: In the case, as the third components, one or more kinds among Si, Zr, Hf, Y, Nb, Nd and Cr are added, the oxidation-resistance of the coating film is improved. When the diffraction intensities of the (200) plane and the (111) plane are respectively defined as I (200) and I (111), the ratio of I (200)/I (111) is regulated to ≥ 2 . In the case of >2 , it can not show sufficient wear resistance in the cutting of a high hardness material in which the temp. of the cutting edge is made high. The thickness of the metallic layer to be interposed on the space between the substrate and the coating is regulated to 2 to 1000 nm. In the case of the lower limit or below, it has no effect on the improvement of the adhesion of the coating film, and in the case of above the upper limit, slippage is generated in the metallic layer, and the coating film is made easy to peel.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] In the covering hard tool which covered to the multilayer the monolayer of the nitride which the rate of an atomic ratio of Ti/aluminum becomes from Ti, aluminum, and the third component of 95/5 to 25/75, a charcoal nitride, a charcoal nitric oxide, *****, and a **** boride, or two sorts or more. The diffraction intensity of the field in the X-ray diffraction (200) of this TiAl and the compound coat of a third component I (200). When the diffraction intensity of a field is set to I (111), the ratio of I (200)/I (111) is two or less. (111) A third component is one sort of Si, Zr, Hf, Y, Nb, Nd, and Cr, or two sorts or more. And the covering hard tool characterized by making the metal alloy layer which consists of Ti, TiAl or TiAl which has the thickness of 2 to 1000nm, and a third component intervene between the compound coats of a base, this TiAl, and a third component.

[Claim 2] The covering hard tool characterized by bases being an end mill made from a cemented carbide, and a drill in a covering hard tool according to claim 1.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] The invention in this application is excellent in the adhesion of a coat, and, as a result, relates to the covering hard metal which has the outstanding abrasion resistance.

[0002]

[Description of the Prior Art] Conventionally, although it was general, Ti is made to contain aluminum, the research which raises abrasion resistance and oxidation resistance is made, and various that coats, such as TiN and TiCN, are general-purpose and examples which accept the addition effect of aluminum also exist in JP.8-267306.A in recent years. However, when these examples added aluminum to a coat, the improvement of the coat [itself / which is called the oxidation resistance of a coat and abrasion resistance] was performed. Moreover, although using TiN coat for a substratum is also proposed as technique of improving the adhesion of TiAlN coat so that this number official report may see, the present condition is having come to obtain sufficient adhesion.

[0003]

[Problem(s) to be Solved by the Invention] Recently, the inclination which high-streamlines cutting is strong and a cutting speed and cutting delivery tend to increase. In such a case, as a factor which governs a tool life, the adhesion of a coat will become very important from the abrasion resistance of a coat, and oxidation resistance. Generally the coat which added the aforementioned aluminum has a high residual compression stress, and as a result, the adhesion of a coat is not satisfied enough and is such — high — in the efficiency cutting, the result which a coat often exfoliates and spoils the life of a tool and a reliability is brought. Furthermore, although it is necessary to make the oxidation resistance of a coat improve further in a high speed cutting, still sufficient effect does not accept. Therefore, also in such high efficiency cutting, it is long lasting, and in order to realize stable cutting, it is necessary to raise the adhesion of a coat further. On the other hand, although the research which reduces the residual compression stress of the coat which is the cause of fundamental of degrading adhesion itself is also made in order to raise adhesion, the present condition is having come to see still sufficient effect.

[0004]

[Means for Solving the Problem] By making the coat of a soft metal intervene under the hard anodic oxidation coatings which has the high compressive stress containing aluminum as a result of repeating a research zealously that this invention persons should improve the adhesion of a coat, the absorption relief of the compressive stress with the high hard anodic oxidation coatings containing aluminum is carried out, and it came to acquire the knowledge which can improve the adhesion of a result hard anodic oxidation coatings remarkably. It is effective to add a third component to oxidation-resistant enhancement.

[0005] When high compressive stress exists in a coat, it is the factor in which the high shearing stress resulting from this compressive stress acts on the interface of a coat and a base hard metal, and this shearing stress spoils the adhesion of a coat, and suggests bringing the result which raises the adhesion of a coat as for easing or removing this. That is, it is thought by making a comparatively soft layer intervene between the coat which has high compressive stress, and a base hard metal that the shearing stress which this comparatively soft coat originates in high compressive stress, and generates in an interface was absorbed, and it eased. Moreover, according to the research of this invention persons, although there is also an example between which the nitride of Ti etc. is made to be placed as mentioned above, when the metal layer of Ti is used, it is more effective to relief of stress. It is thought that a metal layer demonstrates an effect target more to the stress relaxation of a coat that an absorbed energy tends to move the trusion high again since Young's modulus is low. Demonstrating the effect in which the direction which, on the other hand, used the nitride of Ti which made aluminum contain etc. was more excellent to the enhancement in adhesion accepted. If few oxidizing zones surely formed exist when this is put on the front face of a base hard metal into air, although the adhesion of a coat deteriorates remarkably, the result which the thermite reaction which returns this oxidizing zone into the coat formed as a substratum at the time of coating start when aluminum recognizes little presence occurs, removes an oxidizing zone, and improves the adhesion of a coat remarkably will be brought. This is a ***** thing at the principle which the oxygen of the oxidizing zone on the front face of a base and the ion of aluminum react, and forms an oxide in a coat since the oxide of aluminum is low and a free energy of formation is very easy to be formed, and removes the oxidizing zone on the front face of a base.

[0006] The residual compression stress of the coat [itself] depends on coating conditions strongly. Generally, in coating under the condition that the energy of ion is low, the residual compression stress of a coat brings a low result, and the residual compression stress of a coat becomes high in coating under the condition that the energy of ion is high, on the contrary. The bias voltage and the degree of vacuum which are mainly given to a base determine the energy of ion. According to the research of this invention persons, when residual stress of a coat is high, the hardness of a coat tends to carry out orientation of the coat to (111) in X-ray diffraction again highly. In recent years, it must be in the inclination to be used when a cemented-carbide end mill cuts high degree-of-hardness material at high speed, and since the edge of a blade becomes an elevated temperature in such cutting, much more abrasion resistance must be demanded and the degree of hardness of a coat must be high. Moreover, since oxidization occurs, under such a cutting conditions, the oxidation resistance of a coat is demanded much more.

[0007] As a result of this invention person's trying addition of various third components to an oxidation-resistant improvement, in Si, Hf, Y, Zr, Cr, Nb, and Nd, it became clear to carry out a segregation to the grain boundary of the coat of TiAlN, and to suppress a diffusion of the oxygen in a grain boundary, and these third components brought the result whose oxidation resistance of a coat improves remarkably.

[0008] Next, the ground which limited the numeric value is described. In the hard layer, as for the content of aluminum, lower ***** and the addition effect of aluminum do not accept 5%, the abrasion resistance and the oxidation resistance of a coat did not improve, but since the result which ***** hardness falls to the property as AlN, and spoils the abrasion resistance of a coat would be brought if it is made to contain exceeding 75%, Ti / aluminum ratio was set to 95/5 to 25/75. The residual compression stress of the coat was low, and since a degree of hardness was not able to demonstrate sufficient abrasion resistance with Vickers hardness in cutting of the high degree-of-hardness material from which the circumference of lower and the edge of a blade become an elevated temperature about 3000, the ratio of I(200)/I(111) made two or more cases two or less. Moreover, since there was no effect in an improvement of the adhesion of a stress relaxation, i.e., a coat, when this metal layer thickness made to intervene is 2nm or less, and it would bring the result in which a skid occurs and a coat exfoliates easily within a metal layer if 1000nm is exceeded, it could be 2 to 1000nm.

[0009]

[Example] Hereafter, this invention is explained based on an example. In the conditions shown in Table 1 using a small arc ion plating system, coating of the example of this invention manufactured the examples 1-8 of this invention of 3 yuan using the metal target (in addition to Ti and aluminum, the metallic element used the target which added and manufactured the element of Si, Hf, Y, Nb, Nd, and Zr.) of a system using the end mill made from a cemented carbide. The examples 9-12 of a comparison coated using the target of Ti or TiAl, and manufactured the end mill made from a covered cemented carbide. Moreover, in coating of an alloy metal layer, the introduction of nitrogen gas was stopped and was performed.

[0010]

[Table 1]

| 試料 番号 | コーティング条件 | | 皮膜 第1層 全膜層 | 皮膜 第2層 硬質層 | I(200) / I(111) | 折損時の 切削長 (m) | |
|------------------|---------------|-------------|----------------------|--|--|--------------------|------|
| | バイアス 電圧(V) | 真空度 mbar | | | | | |
| 本 発 明 例 | 1 | 300 | 4 × 10 ⁻³ | Ti 3nm | Ti _{0.9} Al _{0.1} Si _{0.1} N | 0.6 | 25.5 |
| | 2 | ↑ | ↑ | Ti 100nm | Ti _{0.9} Al _{0.1} Hf _{0.1} N | 0.4 | 31.4 |
| | 3 | ↑ | ↑ | Ti 850nm | Ti _{0.9} Al _{0.1} Y _{0.1} N | 0.8 | 27.8 |
| | 4 | ↑ | ↑ | Ti _{0.9} Al _{0.1} Nb _{0.1} 100nm | Ti _{0.9} Al _{0.1} Nb _{0.1} N | 0.8 | 29.8 |
| | 5 | ↑ | ↑ | Ti _{0.9} Al _{0.1} Nd _{0.1} 100nm | Ti _{0.9} Al _{0.1} Nd _{0.1} N Ti _{0.9} Al _{0.1} Nd _{0.1} N の交互 15 層 | 1.5 0.3 | 24.5 |
| | 6 | ↑ | ↑ | Ti _{0.9} Al _{0.1} Zr _{0.1} 100nm | Ti _{0.9} Al _{0.1} Zr _{0.1} N Ti _{0.9} Al _{0.1} Zr _{0.1} N の交互 30 層 | 1.5 12.9 | 24.5 |
| | 7 | ↑ | ↑ | Ti _{0.9} Al _{0.1} Nb _{0.1} 600nm | Ti _{0.9} Al _{0.1} Nb _{0.1} N | 0.9 | 21.8 |
| | 8 | ↑ | ↑ | Ti _{0.9} Al _{0.1} Nb _{0.1} N 100nm | Ti _{0.9} Al _{0.1} Nb _{0.1} N | 0.6 | 27.9 |
| 比 較 例 | 9 | 100 | ↑ | free | Ti _{0.9} Al _{0.1} N | 5.6 | 8.8 |
| | 10 | ↑ | ↑ | free | Ti _{0.9} Al _{0.1} N | 7.4 | 4.5 |
| | 11 | ↑ | ↑ | TiN 0.1μ | * | 5.7 | 6.8 |
| | 12 | ↑ | ↑ | TiN 1.0μ | Ti _{0.9} Al _{0.1} N | 6.8 | 10.3 |

[0011] It cut until it performed the cutting test and it broke in the following cutting conditions with the obtained end mill. The length of cut at the time of breakage occurring was written together to Table 1. End mill φ18mm Six sheet ***** material SKD11 HRC 60 cutting speeds It sends 20m / min. 0.06mm / blade slitting 12mm x 0.8mm cutting method Dry-type cutting (Dry)

[0012] In the examples 1-8 of this invention, since cutting of quantity degree-of-hardness material also had little sublation of a coat, and that of long distance cutting was possible, since the metal layer or the alloy metal layer is made to intervene and the coat has stuck well, and orientation of the coat was carried out to (200), abrasion resistance also came out enough and stable cutting has been realized, so that more clearly than Table 1. Moreover, since oxidation resistance was raised and it closed by adding the third element, abrasion resistance can be raised more.

[0013] Next, coating of the examples 13-20 of this invention and the examples 21-24 of a comparison was performed to the end mill made from a cemented carbide on the ***** conditions shown in Table 2, it cut in the following cutting items, and the abrasion loss after 50m cutting was calculated. In this example, the thickness of a coat was unified to 2.0 micrometers.

End mill Two sheet blade **ed [phi10mm] material S50C HRC12 cutting speed It sends 100m / min. 0.1mm / blade slitting 10mmx1mm cutting method Abrasion loss is written together to the dry-type (Dry) cutting table 2.

[0014]

[Table 2]

| 試料 番号 | コーティング条件 | | 皮膜 | | | 厚膜量 (nm) | |
|------------------|---------------|-------------|--------------------|--|--------------|--|-------|
| | バイアス 電圧(V) | 真空度 mbar | 金属層 | 1200V Hilly | 硬質層 | | |
| 本 発 明 例 | 1 | 300 | 4×10^{-2} | Ti 3nm | 0.55 | Ti _{0.5} Al _{0.5} Si _{0.1} N | 0.151 |
| | 2 | ↑ | ↑ | Ti 100nm | 0.67 | Ti _{0.5} Al _{0.5} Hf _{0.1} N | 0.145 |
| | 3 | ↑ | ↑ | Ti 750nm | 0.98 | Ti _{0.5} Al _{0.5} Nb _{0.1} N | 0.143 |
| | 4 | ↑ | ↑ | Ti _{0.5} Al _{0.5} 100nm | 0.37 | Ti _{0.5} Al _{0.5} Nd _{0.1} N | 0.164 |
| | 5 | ↑ | ↑ | Ti _{0.5} Al _{0.5} Cr _{0.1} 50nm | 0.45 0.67 | Ti _{0.5} Al _{0.5} Cr _{0.1} N Ti _{0.5} Al _{0.5} Cr _{0.1} N の交互 30 層 | 0.187 |
| | 6 | ↑ | ↑ | Ti _{0.5} Al _{0.5} Y _{0.1} 100nm | 1.67 0.58 | Ti _{0.5} Al _{0.5} Y _{0.1} N Ti _{0.5} Al _{0.5} Y _{0.1} N の交互 50 層 | 0.163 |
| | 7 | ↑ | ↑ | Ti _{0.5} Al _{0.5} 100nm | 0.77 | Ti _{0.5} Al _{0.5} Si _{0.1} N | 0.135 |
| | 8 | ↑ | ↑ | Ti _{0.5} Al _{0.5} | 0.48 | Ti _{0.5} Al _{0.5} Si _{0.1} N | 0.166 |
| 比 較 例 | 9 | 100 | ↑ | Free | 5.47 | Ti _{0.5} Al _{0.5} N | 0.356 |
| | 10 | ↑ | ↑ | Free | 8.66 | Ti _{0.7} Al _{0.3} N Ti _{0.5} Al _{0.5} N の交互 15 層 | 0.379 |
| | 11 | ↑ | ↑ | TiN 0.1μ | 8.22 | Ti _{0.5} Al _{0.5} N | 0.406 |
| | 12 | ↑ | ↑ | TiN 1.0μ | 6.78 | ↑ | 0.422 |

[0015] In the example of this invention in which a metal layer or an alloy metal layer is made to intervene, and the coat is carrying out orientation to (200), a covering end mill realizes cutting whose adhesion of a coat was good and was extremely stabilized by high-speed high delivery so that more clearly than Table 2. Moreover, in high-speed high delivery, it is in the inclination that edge-of-a-blade temperature becomes high, the oxidation-resistant effect was demonstrated, and the long lasting coat was obtained.

[0016] Furthermore, coating shown in the drill made from a cemented carbide (**** phi6mm) on the coating conditions shown in Table 3 at the examples 25-29 of this invention and the examples 31-32 of a comparison was performed, and it examined by the cutting item shown below.

**ed material SCM440 cutting speed It sends 70m / min. 0.1mm / rev hole depth 15mm cutting method Wet (Wet) Also in this example, the thickness of a coat could be 3.0micro.

The abrasion loss of the edge of a blade after a 3000 hole manipulation is written together to Table 3.

[0017]

[Table 3]

| 試料 番号 | コーティング層 | | | 厚み (mm) |
|------------------|---------|--|--|------------|
| | 金属層 | 硬質層 | I(200)/I(111) | |
| 本 発 明 例 | 1 | Ti _{0.5} Al _{0.5} 80nm | Ti _{0.5} Al _{0.5} Y _{0.1} N 0.67 | 0.211 |
| | 2 | Ti _{0.5} Al _{0.5} 60nm | Ti _{0.5} Al _{0.5} Si _{0.1} N 0.56 | 0.188 |
| | 3 | Ti _{0.5} Al _{0.5} 80nm | Ti _{0.5} Al _{0.5} Nb _{0.1} N 0.47 | 0.199 |
| | 4 | Ti _{0.5} Al _{0.5} Nd _{0.1} 400nm | Ti _{0.5} Al _{0.5} Nd _{0.1} N Ti _{0.5} Al _{0.5} Nd _{0.1} N の交互16層 0.39 0.49 | 0.231 |
| | 5 | Ti 60nm | Ti _{0.5} Al _{0.5} Nb _{0.1} N 0.55 | 0.222 |
| 比 較 例 | 6 | Free | Ti _{0.5} Al _{0.5} N 7.87 | 2789 欠折損 |
| | 7 | Free | Ti _{0.5} Al _{0.5} N 3.99 | 0.468 |
| | 8 | TiN 1.0μ | Ti _{0.5} Al _{0.5} N 8.67 | 0.501 |

[0018] While the metal layer or the alloy metal layer could be made to intervene, it stuck by the tool which includes continuous cutting like a drill and it had abrasion resistance, what added the element which is excellent in oxidation resistance was more effective so that more clearly than Table 3.

[0019] Next, since [synergistic-effect-like / oxidation resistance] it was not able to express, the coat which includes the addition effect of various third components for a third component was coated like the previous example, and it was made to oxidize in 900 degrees C and the atmospheric air in cutting for 1 hour. The thickness of the oxidizing zone formed then was measured by cross-section observation. The result is shown in Table 4.

[0020]
[Table 4]

| 試料 番号 | 皮 膜 | 酸化層厚さ (μm) |
|------------------|---|------------|
| | Ti _{0.5} Al _{0.5} Si _{0.1} N | 1.2 |
| 本 発 明 例 | Ti _{0.5} Al _{0.5} Si _{0.2} N | 0.7 |
| | Ti _{0.5} Al _{0.5} Zr _{0.1} N | 1.5 |
| | Ti _{0.5} Al _{0.5} Zr _{0.2} N | 1.0 |
| | Ti _{0.5} Al _{0.5} Hf _{0.1} N | 1.3 |
| | Ti _{0.5} Al _{0.5} Y _{0.1} N | 0.9 |
| | Ti _{0.5} Al _{0.5} Y _{0.2} N | 0.6 |
| | Ti _{0.5} Al _{0.5} Nb _{0.1} N | 1.6 |
| | Ti _{0.5} Al _{0.5} Nb _{0.2} N | 1.0 |
| | Ti _{0.5} Al _{0.5} Nd _{0.1} N | 0.7 |
| | Ti _{0.5} Al _{0.5} N | 3.2 |
| 比 較 例 | Ti _{0.5} Al _{0.5} N | 2.7 |
| | TiN | 6 |
| | TiCN | 6 |

[0021] Oxidation resistance was expressed with the thickness which oxidizes from a front face as the standard. If oxidation advances to the interior of membranous, cubical expansion arises by oxidation, and a layer separates or will be away held by cutting. Therefore, if oxidation is stopped only near the front face, although a front face will serve as an oxide, since the layer with the precise interior is maintained, it has function sufficient as a tool. Especially, the effect was remarkable at Y, Si, and Nb.

[0022]

[Effect of the Invention] By reducing the stress which prepares a metal or an alloy metal layer between base-coats, and remains the adhesion of a coat to a coat, as explanation was given [above-mentioned] It can act and bite with milling cutter cutting, an end mill, a drill, etc., and sufficient adhesion also for the impact at the time can be maintained. By being able to demonstrate the abrasion resistance of coat original, and the coat's controlling I(200) / I(111) ratio for a stacking tendency or less to two, and adding a third component to it While the abrasion resistance which bore and

rubbed against impact and was excellent in wear was demonstrated, it was able to consider as the coat excellent in oxidation resistance.

[Translation done.]

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開平11-131216

(43) 公開日 平成11年(1999) 5月18日

(51) Int.Cl.⁶

識別記号

F I

C 2 3 C 14/06

C 2 3 C 14/06

N

B 2 3 B 27/14

B 2 3 B 27/14

A

審査請求 未請求 請求項の数 2 F D (全 7 頁)

(21) 出願番号 特願平9-312817

(22) 出願日 平成9年(1997)10月29日

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最終頁に続く

(54) 【発明の名称】 被覆硬質工具

(57) 【要約】

【課題】 Ti、Al及び第三成分からなる化合物を被覆した工具において、皮膜の密着性を改善し、かつ、耐酸化性の向上を計った工具を提供することを目的とする。

【解決手段】 Ti、Al及び第三成分からなる化合物を被覆した工具において、該TiAl及び第三成分の化合物皮膜のX線回折における(200)面の回折強度をI(200)、(111)面の回折強度をI(111)とした場合にI(200)/I(111)の比が2以下であり、第三成分はSi、Zr、Hf、Y、Nb、Nd、Crの1種もしくは2種以上であり、かつ基体と該TiAlと第三成分の化合物皮膜の間に2nmから1000nmの厚さを有するTi、TiAl若しくはTiAlと第三成分よりなる金属合金層を介在させる。

【特許請求の範囲】

【請求項1】 Ti/AI の原子比率が95/5から25/75の Ti と AI 及び第三成分からなる窒化物、炭窒化物、炭窒酸化物、窒酸化物、炭窒酸化物の単層もしくは二種以上を多層に被覆した被覆硬質工具において、該 $TiAI$ 及び第三成分の化合物皮膜のX線回折における(200)面の回折強度を $I(200)$ 、(111)面の回折強度を $I(111)$ とした場合に $I(200)/I(111)$ の比が2以下であり、第三成分は Si 、 Zr 、 Hf 、 Y 、 Nb 、 Nd 、 Cr の1種もしくは2種以上であり、かつ基体と該 $TiAI$ と第三成分の化合物皮膜の間に2nmから1000nmの厚さを有する Ti 、 $TiAI$ 若しくは $TiAl$ と第三成分よりなる金属合金層を介在させたことを特徴とする被覆硬質工具。

【請求項2】 請求項1記載の被覆硬質工具において、基体が超硬合金製エンドミル、ドリルであることを特徴とする被覆硬質工具。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、皮膜の密着性に優れ、その結果、優れた耐摩耗性を有する被覆硬質合金に関する。

【0002】

【従来の技術】従来、 TiN 、 $TiCN$ 等の皮膜が汎用的、かつ、一般的であったが、近年、 Ti に Al を含有させ、耐摩耗性・耐酸化性を向上させる研究がなされ、特開平8-267306号公報には、 Al の添加効果を認める事例も種々存在する。しかしながら、これらの事例は皮膜に Al を添加することにより、皮膜の耐酸化性、耐摩耗性といった皮膜そのものの改善が行われたにすぎない。また、 $TiAlN$ 皮膜の密着性を改善する方法として、同号公報にみられるように、 TiN 皮膜を下地に用いることも提案されているが、十分な密着性を得るに至っていないのが現状である。

【0003】

【発明が解決しようとする課題】最近では、切削を高効率化する傾向が強く、切削速度ならびに切削送りは増加する傾向にある。このような場合工具寿命を支配する因子としては、皮膜の耐摩耗性、耐酸化性よりも皮膜の密着性が極めて重要なものとなる。前記 Al を添加した皮膜は一般に残留圧縮応力が高く、その結果皮膜の密着性が十分満足されるものでなく、この様な高効率な切削加工においては、しばしば皮膜が剥離し工具の寿命、信頼性を損なう結果となっている。さらに、高速切削においてはさらに皮膜の耐酸化性を向上せしめる必要があるがいまだ十分な効果は認められていない。従って、この様な高効率切削においても、長寿命でかつ安定した切削を実現するためには、皮膜の密着性をさらに高める必要がある。一方、密着性を向上させるために、密着性を劣化させる根本原因である皮膜の残留圧縮応力そのものを低

減させる研究もなされてはいるが、いまだ十分な効果を見るに至っていないのが現状である。

【0004】

【課題を解決するための手段】本発明者らは皮膜の密着性を改善すべく鋭意研究を重ねた結果、 Al を含有する高い圧縮応力を有する硬質皮膜の下に軟らかい金属の皮膜を介在させることにより、 Al を含有する硬質皮膜の高い圧縮応力は吸収緩和され、結果硬質皮膜の密着性を著しく改善できる知見を得るに至った。耐酸化性の向上に対しては第三成分を添加することが有効である。

【0005】

皮膜に高い圧縮応力が存在する場合には、皮膜と基体硬質合金の界面にこの圧縮応力に起因する高い剪断応力が作用し、この剪断応力が皮膜の密着性を損なう要因であり、これを緩和、もしくは除去することが皮膜の密着性を向上させる結果となることを示唆するものである。つまり、高い圧縮応力を有する皮膜と基体硬質合金の間に比較的軟らかい層を介在させることにより、この比較的軟らかい皮膜が高い圧縮応力に起因して界面に発生する剪断応力を吸収、緩和したものと考えられる。また、前述したように、 Ti の窒化物等を介在させる事例もあるが、本発明者らの研究によれば、 Ti の金属層を用いた場合、より応力の緩和に対して効果的である。金属層は吸収エネルギーが高くまたヤング率が低いいため転位が移動し易く皮膜の応力緩和に対しより効果的を発揮するものと考えられる。一方、 Al を含有させた Ti の窒化物等を用いた方が密着性の向上に対してはより優れた効果を発揮することが認められた。これは、基体硬質合金の表面に空気中に置いておいたときに必ず形成される僅かな酸化層が存在すると皮膜の密着性は著しく劣化するが、下地として形成される皮膜中に Al が少量存在することによりコーティング開始時に、この酸化層を還元するテルミット反応が起き酸化層を除去し皮膜の密着性を著しく改善する結果をもたらす。これは Al の酸化物は生成自由エネルギーが低く極めて形成されやすいため基体表面の酸化層の酸素と Al のイオンが反応して皮膜内に酸化物を形成し、基体表面の酸化層を除去する原理に基づくものである。

【0006】

皮膜そのものの残留圧縮応力はコーティング条件に強く依存する。一般にイオンのエネルギーが低い条件下のコーティングにおいては、皮膜の残留圧縮応力は低い結果となり、反対にイオンのエネルギーが高い条件下のコーティングにおいては、皮膜の残留圧縮応力は高くなる。イオンのエネルギーを決定するのは主に基体に付与するバイアス電圧と真空度である。本発明者らの研究によれば皮膜は残留応力が高い場合には皮膜の硬さが高くまたX線回折において皮膜は(111)に配向する傾向にある。近年、超硬合金エンドミルは高硬度材を高速で切削する場合に用いられる傾向にあり、このような切削においては、刃先が高温になるため、より一層の耐摩耗性が要求され、皮膜の硬度は高くなければなら

ない。また酸化が発生するため、このような切削条件下では、より一層皮膜の耐酸化性が要求される。

【0007】耐酸化性の改善に対し本発明者は種々の第三成分の添加を試みた結果Si、Hf、Y、Zr、Cr、Nb、Ndにおいてこれら第三成分はTiAlNの皮膜の結晶粒界に偏析し粒界での酸素の拡散を抑制することが明らかになり、皮膜の耐酸化性が著しく向上する結果となった。

【0008】次に数値を限定した理由を述べる。硬質層においては、Alの含有率は5%を下まわると、Alの添加効果が認められず皮膜の耐摩耗性及び耐酸化性は向上せず、75%を越えて含有させるとAlNとしての特性に近ずき硬さが低下し皮膜の耐摩耗性を損なう結果となるため、Ti/Al比は95/5から25/75とした。I(200)/I(111)の比は2以上の場合は皮膜は残留圧縮応力が低く、硬度がビッカース硬度で3000を下まわり、刃先が高温になる高硬度材の切削においては、十分な耐摩耗性を発揮できないため、2以下とした。また、この介在させる金属層の厚さは2nm

以下であると応力緩和つまり皮膜の密着性の改善に効果がなく、1000nmを越えると金属層内ですべりが発生し皮膜が容易に剥離する結果となるため、2nmから1000nmとした。

【0009】

【実施例】以下、実施例に基づいて本発明を説明する。超硬合金製のエンドミルを用いて、小型アーキイオンプラズマコーティング装置を用いて表1に示す条件において、本発明例のコーティングは3元素の金属ターゲット（金属元素はTi、Alに加え、Si、Hf、Y、Nb、Nd、Zrの元素を添加して製作したターゲットを用いた。）を使用して本発明例1～8を製作した。比較例9～12はTi又はTiAlのターゲットを用いてコーティングを行い被覆超硬合金製のエンドミルを製作した。また、合金金属層のコーティングにおいては、窒素ガスの導入を止めて行った。

【0010】

【表1】

| 試料 番号 | | コーティング条件 | | 皮膜 第1層 金属層 | 皮膜 第2層 硬質層 | I(200) / I(111) | 折損時の 切削長 (m) |
|------------------|----|---------------|--------------------|--|--|--------------------|--------------------|
| | | バイアス 電圧(V) | 真空度 mbar | | | | |
| 本 発 明 例 | 1 | 300 | 4×10^{-2} | Ti 3nm | Ti _{0.5} Al _{0.4} Si _{0.1} N | 0.6 | 25.6 |
| | 2 | ↑ | ↑ | Ti 100nm | Ti _{0.5} Al _{0.4} Hf _{0.1} N | 0.4 | 31.4 |
| | 3 | ↑ | ↑ | Ti 850nm | Ti _{0.5} Al _{0.4} Y _{0.1} N | 0.8 | 27.8 |
| | 4 | ↑ | ↑ | Ti _{0.5} Al _{0.4} Nb _{0.1} 100nm | Ti _{0.5} Al _{0.4} Nb _{0.1} N | 0.6 | 29.8 |
| | 5 | ↑ | ↑ | Ti _{0.5} Al _{0.4} Nd _{0.1} 100nm | Ti _{0.5} Al _{0.4} Nd _{0.1} N Ti _{0.5} Al _{0.4} Nd _{0.1} N の交互15層 | 1.6 0.3 | 24.5 |
| | 6 | ↑ | ↑ | Ti _{0.7} Al _{0.2} Zr _{0.1} 100nm | Ti _{0.7} Al _{0.2} Zr _{0.1} N Ti _{0.5} Al _{0.4} Zr _{0.1} N の交互30層 | 1.6 12.9 | 24.5 |
| | 7 | ↑ | ↑ | Ti _{0.7} Al _{0.1} Nb _{0.2} 500nm | Ti _{0.7} Al _{0.1} Nb _{0.2} N | 0.9 | 21.8 |
| | 8 | ↑ | ↑ | Ti _{0.4} Al _{0.4} Nb _{0.2} N 100nm | Ti _{0.4} Al _{0.4} Nb _{0.2} N | 0.6 | 27.9 |
| 比 較 例 | 9 | 100 | ↑ | free | Ti _{0.5} Al _{0.5} N | 5.6 | 8.8 |
| | 10 | ↑ | ↑ | free | Ti _{0.5} Al _{0.5} N | 7.4 | 4.5 |
| | 11 | ↑ | ↑ | TiN 0.1μ | ↑ | 5.7 | 6.8 |
| | 12 | ↑ | ↑ | TiN 1.0μ | Ti _{0.5} Al _{0.5} N | 6.8 | 10.3 |

【0011】得られたエンドミルで次の切削条件にて切削テストを行い、折損するまで切削を行った。折損が発生した時点の切削長を表1に併記した。

エンドミル φ8mm 6枚刃

被削材 SKD11 HRC 60

切削速度 20m/min

送り 0.06mm/刃

切り込み 12mm x 0.8mm

切削方式 乾式切削 (Dry)

【0012】表1より明らかなように、本発明例1～8では、金属層又は合金金属層を介在させているため皮膜が良く密着しているため高硬度材の切削でも皮膜の剥離が少なく、長い距離切削ができ、また皮膜を(200)に配向させているため耐摩耗性も十分に安定な切削が実現出来た。また第三元素を添加することにより耐酸化性を向上させしめたのでより耐摩耗性を向上させることが出来たものである。

【0013】次に、表2に示すコーティング条件で超硬

合金製エンドミルに本発明例13~20と比較例21~24のコーティングを行い、以下の切削諸元にて切削を行い50m切削後の摩耗量を求めた。本実施例では皮膜の厚さを2.0 μ mに統一した。

エンドミル 2枚刃 Φ 10mm

被削材 S50C HRC12

切削速度 100m/min

送り 0.1mm/刃

切り込み 10mm \times 1mm

切削方式 乾式(Dry)切削

表2に摩耗量を併記する。

【0014】

【表2】

| 試料 番号 | コーティング条件 | | 皮膜 | | | 摩耗量 (mm) | |
|------------------|---------------|-------------|----------------------|--|--------------|--|-------|
| | バイアス 電圧(V) | 真空度 mbar | 金属層 | 1000V I(111) | 硬質層 | | |
| 本 発 明 例 | 1 | 300 | 4 × 10 ⁻² | Ti 3nm | 0.55 | Ti _{0.5} Al _{0.4} Si _{0.1} N | 0.151 |
| | 2 | ↑ | ↑ | Ti 100nm | 0.67 | Ti _{0.5} Al _{0.4} Hf _{0.1} N | 0.145 |
| | 3 | ↑ | ↑ | Ti 750nm | 0.98 | Ti _{0.5} Al _{0.4} Nb _{0.1} N | 0.143 |
| | 4 | ↑ | ↑ | Ti _{0.5} Al _{0.1} 100nm | 0.37 | Ti _{0.5} Al _{0.4} Nd _{0.1} N | 0.164 |
| | 5 | ↑ | ↑ | Ti _{0.5} Al _{0.1} Cr _{0.1} 50nm | 0.45 0.67 | Ti _{0.5} Al _{0.1} Cr _{0.1} N Ti _{0.5} Al _{0.4} Cr _{0.1} N の交互 30 層 | 0.167 |
| | 6 | ↑ | ↑ | Ti _{0.5} Al _{0.1} Y _{0.1} 100nm | 1.67 0.56 | Ti _{0.5} Al _{0.1} Y _{0.1} N Ti _{0.5} Al _{0.4} Y _{0.1} N の交互 50 層 | 0.163 |
| | 7 | ↑ | ↑ | Ti _{0.5} Al _{0.5} 100nm | 0.77 | Ti _{0.5} Al _{0.4} Si _{0.1} N | 0.135 |
| | 8 | ↑ | ↑ | Ti _{0.5} Al _{0.5} | 0.48 | Ti _{0.5} Al _{0.4} Si _{0.1} N | 0.166 |
| 比 較 例 | 9 | 100 | ↑ | Free | 5.47 | Ti _{0.5} Al _{0.5} N | 0.356 |
| | 10 | ↑ | ↑ | Free | 8.56 | Ti _{0.7} Al _{0.3} N Ti _{0.5} Al _{0.5} N の交互 15 層 | 0.379 |
| | 11 | ↑ | ↑ | TiN 0.1 μ | 8.22 | Ti _{0.5} Al _{0.5} N | 0.406 |
| | 12 | ↑ | ↑ | TiN 1.0 μ | 6.78 | ↑ | 0.422 |

【0015】表2より明らかなように、金属層又は合金金属層を介在させ、かつ、皮膜が(200)に配向している本発明例では、被覆エンドミルは皮膜の密着性が良好で高速高送りでも極めて安定した切削を実現するものである。また、高速高送りでは刃先温度が高くなる傾向

にあり、耐酸化性の効果が発揮され、長寿命な皮膜が得られた。

【0016】更に、表3に示すコーティング条件にて超硬合金製ドリル(刃径 Φ 6mm)に本発明例25~29、並びに比較例31~32に示すコーティングを行

い、以下に示した切削諸元により試験を行った。

被削材 SCM440

切削速度 70m/min

送り 0.1mm/rev

穴深さ 15mm

切削方式 湿式 (Wet)

本実施例においても、皮膜の膜厚は3.0μとした。

表3に3000穴加工後の刃先の摩耗量を併記する。

【0017】

【表3】

| 試料 番号 | コーティング層 | | | 摩耗量 (mm) |
|------------------|---------|--|--|--------------|
| | | 金属層 | 硬質層 | |
| 本 発 明 例 | 1 | Ti _{0.5} Al _{0.1} 5nm | Ti _{0.5} Al _{0.4} Y _{0.1} N | 0.67 |
| | 2 | Ti _{0.5} Al _{0.1} 50nm | Ti _{0.5} Al _{0.4} Si _{0.1} N | 0.55 |
| | 3 | Ti _{0.5} Al _{0.1} 800nm | Ti _{0.5} Al _{0.4} Nb _{0.1} N | 0.47 |
| | 4 | Ti _{0.5} Al _{0.1} Nd _{0.1} 400nm | Ti _{0.5} Al _{0.1} Nd _{0.1} N Ti _{0.5} Al _{0.4} Nd _{0.1} N の交互15層 | 0.39 0.49 |
| | 5 | Ti 50nm | Ti _{0.4} Al _{0.4} Nb _{0.2} N | 0.55 |
| 比 較 例 | 6 | Free | Ti _{0.5} Al _{0.5} N | 7.87 |
| | 7 | Free | Ti _{0.5} Al _{0.5} N | 5.99 |
| | 8 | TiN 1.0μ | Ti _{0.5} Al _{0.5} N | 8.57 |

【0018】表3より明らかなように、ドリルのように連続的な切削を含む工具では、金属層又は合金金属層を介在させて良く密着し、耐摩耗性を有すると共に耐酸化性に優れる元素を添加したものがより有効であった。

【0019】次に、切削では耐酸化性が相乗効果的にしか表せないため、各種第三成分の添加効果を、第三成分

を含む皮膜を先の実施例同様にコーティングし、900℃、大気中で1時間酸化させた。その時に形成した酸化層の厚さを断面観察にて測定した。その結果を表4に示す。

【0020】

【表4】

| | 皮 膜 | 酸化層厚さ(ミクロン) |
|------------------|--|-------------|
| 本 発 明 例 | $\text{Ti}_{0.5}\text{Al}_{0.4}\text{Si}_{0.1}\text{N}$ | 1.2 |
| | $\text{Ti}_{0.3}\text{Al}_{0.4}\text{Si}_{0.3}\text{N}$ | 0.7 |
| | $\text{Ti}_{0.5}\text{Al}_{0.4}\text{Zr}_{0.1}\text{N}$ | 1.5 |
| | $\text{Ti}_{0.3}\text{Al}_{0.4}\text{Zr}_{0.3}\text{N}$ | 1.0 |
| | $\text{Ti}_{0.5}\text{Al}_{0.4}\text{Hf}_{0.1}\text{N}$ | 1.3 |
| | $\text{Ti}_{0.5}\text{Al}_{0.4}\text{Y}_{0.1}\text{N}$ | 0.9 |
| | $\text{Ti}_{0.3}\text{Al}_{0.4}\text{Y}_{0.3}\text{N}$ | 0.6 |
| | $\text{Ti}_{0.5}\text{Al}_{0.4}\text{Nb}_{0.05}\text{N}$ | 1.5 |
| | $\text{Ti}_{0.5}\text{Al}_{0.4}\text{Nb}_{0.1}\text{N}$ | 1.0 |
| | $\text{Ti}_{0.3}\text{Al}_{0.4}\text{Nd}_{0.3}\text{N}$ | 0.7 |
| 比 較 例 | $\text{Ti}_{0.5}\text{Al}_{0.5}\text{N}$ | 3.2 |
| | $\text{Ti}_{0.4}\text{Al}_{0.5}\text{N}$ | 2.7 |
| | Ti N | 5 |
| | Ti CN | 6 |

【0021】耐酸化性は、その目安として表面から酸化される厚さで現した。酸化が膜の内部まで進行すると酸化により体積膨張が生じ膜は剥がれるか、切削により持ち去られてしまう。そのため酸化を表面近傍のみに食い止められれば表面は酸化物となるが内部は緻密な膜が維持されているため、工具としては十分な機能を有するものとなる。特に、Y、Si、Nbでその効果が顕著であった。

【0022】

【発明の効果】上記説明したように、皮膜の密着性を基

体—皮膜間に金属又は合金金属層を設け、皮膜に残留する応力を低減することにより、フライス切削、エンドミル、ドリル等で作用する食い付き時の衝撃にも十分な密着性を保つことができ、皮膜本来の耐摩耗性を発揮することができ、また、その皮膜は配向性を $I(200)/I(111)$ 比を2以下に制御し、それに第三成分を添加することにより、衝撃に耐え、こすり摩耗に優れた耐摩耗性を発揮するとともに耐酸化性に優れた皮膜とすることができた。

フロントページの続き

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